

PSYCHE.

FRAGMENTS OF THE COARSER ANATOMY OF DIURNAL LEPIDOPTERA.

I. THE LARVA OF *DANAIS PLEXIPPUS*, OF NORTH AMERICA.

BY SAMUEL H. SCUDDER, CAMBRIDGE, MASS.

So very little is known of the points in which different lepidoptera agree or disagree in their internal anatomy, that, although very fragmentary, I venture to publish the following accounts of dissections of caterpillars and chrysalids of butterflies, made about ten years ago, more in the hope of calling attention to the need of work of this kind than of directly contributing to any general statements deducible from the observations.

The literature of the subject is exceedingly scanty. Swammerdam in his *Biblia naturae* (1737) gives illustrations and descriptions of the internal anatomy of the larva of *Aglais urticae*; Herold in his *Entwicklungsgeschichte der Schmetterlinge* (1815) gives admirably full details of the anatomy of both larva and pupa of "*Pieris brassicae*"; Newport gives a section on the Development of the nervous column of "*Vanessa urticae*" in the *Philosophical transactions* for 1834 (repeated in Todd's *encyclopaedia*, art. *Insecta*): and on the Transformations of the tracheae in the same insect in the *Philosophical transactions* for 1836 (also repeated as above): Brandt also figures the meta-

morphoses of the nervous system of the same species in the *Horae societatis entomologicae rossicae* for 1879, v. 15, pl. 14; and in my recent volume on butterflies, quoted below, I have given a brief account of the anatomy of larvae of butterflies in general and of the changes the organs undergo in passing through the pupal condition. So far as I am aware, these are all the notices that have been published of the internal anatomy of the earlier stages, and, as will be seen, they cover a very narrow field, treating, with the exception of my little book, of only two species.

My studies were mostly confined to half a dozen insects, which will be separately treated, commencing with the highest, the account of which will also be fullest.

A good illustration of the general disposition of the organs of the caterpillar of *Danais plexippus*, drawn on a side view by Mr. Edward Burgess, will be found in my recently published book on butterflies,* fig. 78, and this may be

*Butterflies: their structure, changes and life histories, with special reference to American forms. . . . New York. Henry Holt & Co., 1881. 6¢

readily used in connection with the following description.

Muscular system. The head is mostly filled with conical muscular bundles, attached by their bases to the upper and lateral portions of the posterior two-thirds, and to some extent to the upper portion of the anterior third of the vault of the head; the apices of these conical masses converge toward the middle longitudinal line of each hemisphere, and then pass downward, terminating, in the lower half of the head, in a white, glistening, tendinous cord fully a millimetre long, lying just behind the optic nerve and reaching down into the mandibles, which they serve to close. The extensors of the mandibles are attached behind and below the eyespecks, and pass directly to the outer base of the mandibles, which they enter by means of a tendon attached to the interior wall of the same. The retractors of the labrum are slight, flat, muscular ribbons, attached at one extremity along the whole of its upper interior edge and at the other to the facial triangle; the labrum is drawn inwards by a double muscle, which starts above from its attachment along each side of the median suture above the facial triangle, and passes freely downwards, the muscles of the two sides confluent and together 0.38 mm. broad, diminishing in breadth downward, and terminating in a single tendon attached to the middle of the labrum.

A band or ribbon, made up of simple, longitudinal, parallel muscular fibres, collected into two contiguous strips, the inner the narrower, runs from one end of the body to the other, near the skin, between the spiracles and the ventral line

of the body; each is made up of a series of bands, one to each segment, extending across its entire length, and they are permeated by minute tracheal vessels running mainly at right angles to the direction of the fibres; from the anterior end of the inner strip of each segment, a slender muscular strap runs obliquely to the middle of the ventral line of the segment. Above the spiracles, on each side, are three muscular ribbons, the lowermost lying nearer the integument than the others, its lower edge touching the base of the tracheae. Beneath all these longitudinal bands, as seen from within, *i. e.*, lying nearer the integument, and at the anterior edge of each segment, a narrow transverse belt encircles the whole body, passing at the stigmatal line over the longitudinal tracheal vessel which unites two contiguous spiracles, and strapping it to the integument.

The flexor muscles of the true legs originate in the body just beneath the origin of the outer of the two longitudinal muscular ribbons of the ventral surface of the body, and extend to the opposite wall of the segment. The muscles of the prolegs consist of flat bands forming a muscular coating to the walls of the legs, passing in a direct line downward, narrowing as they go; they do not cross each other, nor pass to opposite sides of the legs, but are entirely simple.

Passing now to the muscles attached to the internal organs, we find the coating of the stomach, which is a mere film, overlaid by delicate parallel strips of muscular fibres crossing diagonally in opposite directions: besides these there

are longitudinal muscles arranged in sets, each set separated from its neighbors by an interval of about one millimetre, and composed of four slender bands, traversing the entire length of the stomach; those next the dorsal and ventral lines are more prominent than the others and on the anterior are larger than on the posterior half; the sets on the dorsal line are united into a double band at the anterior extremity and pass to the oesophagus, where they are more widely separated: the oesophagus is provided also with other longitudinal muscles, and to a less extent with transverse encircling bands. The small intestine is covered with both transverse and longitudinal bands of thick white and glistening muscular tissue; at its anterior end especially, where the alimentary canal is greatly constricted, it is covered thickly with short longitudinal muscles, whose hinder extremities dovetail into other longer sets; besides these, there arise from the middle of the posterior end of the intestine a number of parallel bands of muscular fibre, which embrace it diagonally, passing around to the ventral surface of its anterior extremity; starting just in front of the posterior insertion of these, and interlacing with them at right angles, is another shorter set of parallel muscles, whose other extremities are attached to the body-wall; still further, a set of four independent parallel muscular bands passes beneath and supports the posterior end of the small intestine, reaching horizontally from the middle of one side of the eighth abdominal segment to the opposite. The colon is furnished simply with longitu-

dinal and transverse muscular bands, heavier than those on the stomach-wall.

Digestive system. The oesophagus is a simple, straight, equal tube 1.5 mm. long, terminating posteriorly in a larger portion swollen in the middle and better provided with muscular bands, 3.5 mm. long and 1.75 mm. broad — a sort of crop, which extends part way into the second thoracic segment. The stomach extends from the middle of the second thoracic to the middle of the seventh abdominal segment and of course varies in size according to the amount of food the creature has swallowed; usually it is about 4 mm. in diameter; the proper wall of the stomach seems to be the merest film, traversed by muscular fibres, which, by lines not deeply impressed, divide the surface into narrow, rounded, transverse, parallel lobes, reaching from the middle of the upper and under surfaces to the middle of each side, and which alone prevent the perfectly free and direct posterior motion of the contents. The stomach itself, however, may be wholly withdrawn, without rupture, from this investing muscular tissue. At the middle of the seventh abdominal segment, the alimentary canal suddenly tapers, and the small intestine commences, extending half-way to the end of the body and consisting of a straight cylindrical tube 2.25 mm. in diameter, surrounded by thick walls of muscular tissue, the longitudinal bands of which mold the interior walls into very prominent longitudinal ridges. The colon is a simple straight tube of the same size as the intestine but capable of considerable expansion, and with a smooth inner

surface.

The salivary glands are a pair of long straight, flat ribbons, arising from each side of the anterior extremity of the oesophagus and extending backward along the alimentary canal; they are 4.75 mm. long, tapering slightly and regularly to a bluntly rounded tip, being 0.34 mm. broad near the base and 0.14 mm. broad close to the tip; they resemble flattened, braided cords, being compressed along the median line, while each side is regularly and deeply excised at frequent intervals, producing bead-like lateral prominences.

The malpighian vessels originate as slender tubes, one on each side of the middle of the anterior half of the intestine; the tube gradually enlarges, and at a distance of 2 mm. from the origin subdivides into three branches (the under branch originating just before the other two), which are strongly waved or crenulated cords, and are, throughout, nearly or quite as large as the tube at its very origin; the under branch passes forward in a tortuous course, above the nervous cord, along and in contact with the under outer surface of the stomach, as far as the middle of the first abdominal segment, where it bends upon itself and returns in a similar manner, a little higher up, to the point from which it started; the two other branches, which are a little smaller than the first, extend forward and then backward in a similar manner, one passing along the upper outer portion of the stomach as far as the second abdominal segment, and then returning, the other along the side of the stomach to the middle of the

first abdominal segment; all three branches pass outside the tracheal tubes which invest the stomach, and when each has returned to the point from which it started, the extremities of the three threads are collected with those of the opposite side, in a single intricate and convoluted mass enveloping the intestine, and covering also the whole surface of the colon with their more delicate terminal threads. When the posterior part of the alimentary canal is pressed, whitish particles can be seen to move in an irregular manner within the malpighian vessels.

Respiratory System. The tracheae of the first abdominal segment are larger and branch more extensively than those of any other segment, their ramifications extending to the anterior extremity of the stomach; while those of the third thoracic segment are small and comparatively inconspicuous and are connected with those of the first abdominal segment by only a small longitudinal canal; the first thoracic segment bears, however, an extensive bunch of tracheae, which is connected with that of the first abdominal segment by a long longitudinal canal, as large as many of the main branches of these two segments.

The anterior branch of this bunch in the first thoracic segment supplies the head; it passes upward on each side along the hinder edge of the head, until it meets that of the opposite side, when the two join so strongly that considerable force is required to part them; and the only mark of separation is a pale line on the dusky surface. As soon as they meet they bend toward the

head, separate again and run side by side beneath the muscular mass which occupies most of the head, over the double cephalic ganglion and curve over toward the labrum. Before these two opposite branches first unite they emit from their anterior surface similar parallel branches, which also run beneath the muscular mass toward the anterior and lower part of the head; some curve upward and embrace the muscular mass from below; half way between the spiracle and the top of the head, this arching branch emits from its posterior surface a slender offshoot, which, together with another branch, coming almost direct from the spiracle, passes toward the tracheae of the opposite side, unites at the median line with a similar set from the opposite tracheae, and then terminates.

Circulatory system. The dorsal vessel is a straight tube, lying along the middle of the back, next the integument, and seems to be composed of an excessively delicate, whitish, pellucid film, is scarcely 0.5 mm. in diameter, uniform throughout, and terminates at the very end of the body in a well rounded tip.

Nervous system. Viewed from above, the cephalic ganglia consist of a pair of short, obovate, nearly globular lobes, closely joined by their inner edges; they are situated in the very middle of the head, just above the commencement of the alimentary canal, and on a level, above, with the top of the frontal triangle. From the lower anterior outer angle of each lobe, the optic nerve, large at base, but gradually tapering beyond, passes downward, forward, and outward, in a

straight course toward the ocelli; as it reaches them it expands into a broad field comprising the ocelli,—black conical masses, their apices plunged in the nervous tissue forming the field. Just behind the origin of the optic nerve another independent nerve arises, extending to the upper portion of the tendinous cord which terminates the great muscular mass of the head and moves the mandibles. A little further removed from the optic nerve, and on the lower anterior edge of each lobe, a little within the middle, another slender nerve arises, which runs in a straight course to the base of the antennae.

From the lower outer edge of each cephalic lobe a nervous cord passes downward and a little backward, the two embracing the oesophagus, and then converges until they unite in the suboesophageal ganglion, a horizontal lenticular disk, situated at the base of the head just above its hinder edge; just beneath the oesophagus these embracing cords are united by a cross thread; this suboesophageal ganglion throws out lateral nerves, directed forward and outward, and is strapped in its place by transverse muscles, one just in front and another just behind it, which originate together on the floor of the body; and the hinder of which is strengthened on each side by a secondary muscle, which runs backward beside the cord for a short distance, divaricating slightly.

The ganglia of the body-segments are situated in or near, generally a little in advance of, the middle of each segment, as far as the seventh abdominal segment, where there is a pair, in close proximity,

one behind the other, and with these the nervous cord terminates. All the ganglionic disks are connected by a pair of ribbons, generally lying in such close proximity as to appear to be single and straight, but anteriorly they are separated somewhat widely.

In leaving the suboesophageal ganglion, the nervous ribbons run nearly parallel, or only slightly curved outward, to the first body-ganglion. Starting again close together at the middle of the posterior border of the first ganglion they diverge in straight lines, but very gradually, for fully two-thirds the distance to the second ganglion (which is twice as far removed from the first as the first is from the suboesophageal ganglion), where they are nearly twice as far apart as the width of the first ganglion, and then converge more rapidly and enter the second ganglion at its outer anterior border. The distance from the second to the third ganglion is effected in a similar manner, the distance from the second ganglion to the point of greatest divergence being about equal to the distance between the first and second ganglia. The fourth ganglion is but little removed from the third, being in fact nearer to it than the latter is to the point of greatest divergence of the ribbons in advance of it; between these two ganglia the ribbon is straight, slightly longer than broad, broader than at any point posteriorly, and its separation into two cords is not readily seen. Behind this the ganglia are nearly equidistant (up to those of the seventh abdominal segment) and connected by a straight double ribbon, scarcely broader than either one of

the cords between the second and third ganglia, and which is seen to be double only by the slight divergence of the cords in advance of each ganglion as they enter it. The last ganglion is situated in the seventh abdominal segment, just posterior to the tenth ganglion; indeed the two appear almost to coalesce at their adjoining edges; the eleventh is slightly the larger of the two. From the second abdominal segment backward, the nervous cord does not come in direct contact with the alimentary canal, but considerable fatty tissue is interposed between them; in advance of this, however, the reverse is the case, the fatty tissue appearing as if strapped in its place between the nervous cord and the integument by the branches of the former.

From each side of each abdominal ganglion two lateral nerves are emitted, the anterior at right angles, the posterior in a slightly posterior direction, and at their bases the two are connected by a delicate film. In the thoracic segments a similar rule holds, but in the first ganglion only the anterior lateral nerve is present, and it is directed forward; the third ganglion on the other hand follows the rule of the abdominal ganglia, while in the second, the nerves are confluent at their origin, directed at right angles outward, and almost immediately diverge at right angles to each other, one forward, the other backward. In addition to the lateral nerves, the terminal ganglion is furnished with two pairs of longer and stouter posterior nerves, reaching into the hinder segments, the outer cords trending somewhat outward.

Silk vessels. These, which have their outlet upon the labium, consist first of a delicate thread running along the sides of the alimentary canal in a tortuous manner to the middle of the second thoracic segment; here, at the lower portion of the sides of the stomach, they thicken rapidly and form the second portion, a slender tube of uniform size, running in a straight course beside and close to the stomach as far as the middle of the third abdominal segment; here it doubles upon itself and returns to the middle of the preceding segment, again repeating the curve in a reverse direction for half the distance, and then passes upward to the upper surface of the stomach and continues in a tortuous course, still hugging the alimentary canal, as far as the sixth abdominal segment, where it terminates in a very slender straight thread, by which it is connected with the sides of the intestine. The length of the basal thread is 12 mm., covering a distance of 4 mm.; the length of the thickened portion during its course on the under surface of the stomach is 18 mm.; during its tortuous course above, 35 mm.; its normal thickness, 0.8 mm., is attained within a distance of 2 mm. from the point of thickening.

Male generative organs. The testes are situated in the middle of the dorsum of the fifth abdominal segment directly above and upon the stomach; they are

soft, plump, kidney-shaped, compound organs, 2.5 mm. long, of a bluish-purple color, covered by an exceedingly thin whitish investment, concealing the color of the interior as by a pale bloom. In a longitudinal row along the middle of the inner side of each half, there are four minute roundish spots of a deeper color, each communicating with a separate chamber within, separated from the others by a thin partition wall; the middle pair of chambers is smaller than the outer one, and they are all filled with a grayish granular matter. From the anterior extremity of each testis runs a short white thread, not half so long as the testis, and thickened in the middle and at the end. Just behind the hindmost spot of each side, a delicate pellucid thread arises, which passes posteriorly and a little downward until opposite the spiracle of the sixth abdominal segment; here it plunges downward toward it, and passing through the mass of tracheae to those of the seventh segment, sweeps around toward the medio-ventral line of the body, and, passing through an independent muscular bundle scarcely larger than itself, which stretches transversely across the body at this point, enters a whitish sac about 0.75 mm. long, situated just beneath the termination of the intestine; the threads are about 13.5 mm. long and 0.03 mm. in diameter.

2. THE PUPA OF *DANAIS PLEXIPPUS*, OF NORTH AMERICA.

All the dissections were made of specimens either seven or nine days in chrysalis.

Digestive system. The oesophagus is

a mere thread-like vessel 0.10—0.15 mm. in diameter, and runs straight to the stomach. The "jabot," or reservoir above the anterior end of the stomach

is shaped in the 7-days' chrysalis much as in the pupa of *Hamadryas io*, to be described further on, and is about 5.25 mm. long, scarcely 1 mm. broad, cylindrical, and at tip bluntly and regularly rounded; in the 9-days' pupa it is flattened, increasing regularly and considerably in size, and at the tip slightly and roundly invaginate; it reaches to the third abdominal segment, being 4.6 mm. long, and its greatest breadth 2.5 mm. Next the opening to the "jabot," the intestinal canal expands to a sort of crop, of an oval shape, scarcely longer than broad, and about 1 mm. long; this opens directly into the stomach, a cylindrical tube, tapering in front, about 8 mm. long, suddenly contracted at its posterior end. The intestine in a 7-days' chrysalis is a rather large, cylindrical tube, fully 6.5 mm. long, and 3 mm. broad, slightly tortuous, especially anteriorly; in the 9-days' chrysalis, however, considerable change has been effected, for the intestine is now 9 mm. long, and only 0.25 mm. in diameter, a little larger at the two extremities, but otherwise equal and much more tortuous; at first it is directed upward, forward and slightly to one side for a short distance, then it doubles upon itself, crosses to the opposite side, and moves upward in a tortuous manner to the colon, which it enters a little behind and to the left of its anterior extremity. The colon in the 7-days' chrysalis is a broadly oval, flattened sac, 1.5 mm. long, and 1.25 mm. broad; in the 9-days' chrysalis it is 3.5 mm. long, and only 1.5 mm. broad, and gradually passes into the broad rectum, which seems only a continuation of it.

In the middle of the thorax the salivary glands form exceedingly fine, crinkled threads, which here collect in a longitudinally disposed mass on each side of and touching the oesophagus; this mass extends over a distance of 2.5 mm. and the thread finally ends in a bulbous enlargement about 0.2 mm. in diameter.

The malpighian vessels begin to branch at a distance from their origin scarcely greater than their diameter, and the second division occurs at even a less distance beyond the first; one of the latter branches extends along the superior lateral walls of the stomach, as far as the middle of its anterior half (perhaps farther, later in life) and then returns; the other branch of the outer set passes along the inferior lateral walls of the stomach; they are all very delicate, measuring but 0.04 mm. in diameter, and after their return are strongly convoluted, enwrapping the intestine but not the colon.

Respiratory system. The branchial tubes in the posterior part of the body are small, but from the third abdominal segment forward they commence to enlarge; this is especially noticeable in the longitudinal canals, which are largest in the first abdominal segments, 0.8 mm. in diameter, and are again reduced in size in the thorax, where they are from 0.20 to 0.35 mm. in diameter.

Circulatory system. The dorsal vessel is firmly attached to the integument between the fourth and sixth abdominal segments, which is not the case anteriorly; on all the abdominal segments, behind the first, it expands laterally at the posterior limits of the segment, so

as to be at least 0.5 mm. in diameter; on the first segment it broadens slightly, and in front of the expansion commences to diminish gradually and slightly in size, so that when it enters the thorax (from the abdomen) it becomes reduced to a diameter of only 0.20—0.25 mm. As soon as it enters the thorax it begins to plunge downward, until the constriction of the metathorax is passed, or during a course of about 3 mm. It then increases gradually in size again to about 0.45 mm., but instead of running directly to the head it passes in an oblique direction upward between the muscles of each side of the body, and when it has nearly traversed the thorax doubles upon its course, passing beneath the portion already mentioned, and then turns back again beneath its former course toward the head; the trebled portion extends over an area fully 5 mm. long, and no such marked mesothoracic enlargement as occurs in the imago was noticed; when it enters the head it has become reduced to a slender thread about as large as the oesophagus. The whole dorsal vessel from the head to the fourth abdominal segment (behind which it becomes much reduced and obscure) is 30 mm. long, when extended.

Nervous system. In the 7-days' chrysalis a great nervous mass is seen a little in advance of the middle of the thorax, a little larger than that of *Hamadryas*; the lateral nerves from it appear to be double at their origin, and to be inclined forward; behind this ganglion the cord is very slender, and at a distance of 4.5 mm. from the extremity of the ganglion emits a pair of slender but very distinct nerves, which are

directed backward but divaricate considerably; there is no ganglionic enlargement at their origin. At a distance of a millimetre and a half behind this, where the cord enters the abdomen, it becomes and thereafter continues stouter, being enclosed in a nebulous wrapping, described by Dufour in the abdomen of the imago of other lepidoptera as a fibro-muscular, white membrane. At a further distance of 2.75 mm. we come to an exceedingly slight ganglioniform swelling, having no lateral nerves springing from it; probably this is what Dufour refers to as a white, fibrous, ellipsoidal capsule embracing the cord at this point. The last two ganglia are 1.25 mm. apart, measuring from their posterior extremities.

In front of the thoracic ganglion the cord is stout, 0.15 mm. in diameter; from the ganglion to where it divides around the oesophagus is 1.5 mm., and the forks are about 0.5 mm. long.

In a 9-days' chrysalis the cord has not yet attained its complete development, as is readily seen by its sinuous course between the thoracic enlargement and the lateral nerves, which diverge from the cord before the abdomen is reached, where, in a distance of 3.5 mm., the cord is 4.5 mm. long, making three sinuous curves in reaching this point; these nerves pass not to the legs but to the inflated longitudinal branchial canals; they originate 1.7 mm. in advance of the abdominal line, and 2.8 mm. behind the thoracic mass.

The nervous cord apparently enlarges as it reaches the abdomen, being enveloped in a thin film in which the lateral nerves run. The first abdominal ganglion

emits an anterior lateral nerve, and at three-fifths the distance to the second abdominal ganglion another set appears, as well as still another pair just in front of the second ganglion, at only the distance of the breadth of the ganglion from it; an anterior lateral nerve is also thrown off from each side of the second ganglion, which is 3 mm. distant from the first, and another pair on the cord midway between the second and third ganglia which are 1.9 mm. apart; a similar anterior nerve to the third ganglion forks when it has passed a ganglion's breadth away. The last ganglion is 1.3 mm. distant from the third (measured from their centres) and emits several nerves; from the outer edges of the posterior border a pair of stout nerves run parallel to each other; from just behind the middle of the sides another pair arises, and nearer them than the posterior pair still another—all running backward; from the outer edges of the anterior border runs another pair, which forks almost at origin, one branch passing somewhat forward, the other somewhat backward.

Female generative organs. The basal stems of the ovarian tubes in the 7-days' chrysalis are 1.25 mm. long and 0.25 mm. broad; they suddenly diminish in size beyond this to about half this diameter, and then, in a distance of 4 mm., course forward and backward three times. The portion of the ovarian tubes between the oviduct and their own division is 2 mm. long and about twice the diameter of the divided tubes. Just beneath the anterior extremity of the colon, the oviduct expands into a broadly oval sac, scarcely longer than broad,

about 0.65 mm. long, into which opens a canal 1.25 mm. long, which expands into a subreniform vessel, the spermatheca, 0.8 mm. long and about 0.5 mm. broad, terminating at its interior, anterior extremity in a slender curving tube about 0.12 mm. in diameter.

In the 9-days' (perhaps overlooked in the 7-days') chrysalis, the tips of the ovarian tubes are united into a single mass for a distance of 2 mm. and extend beyond the reduplicated portion, which extends over 6 mm. distance; the basal stems of these tubes before their union are 0.4 mm. in diameter and 2 mm. long, uniting on each side of and rather above the extremity of the stomach to form a single tube, also 2 mm. long and no stouter than its branches.

As the anterior extremity of the stomach is overlaid by the reservoir, so the posterior end is covered by the copulatory pouch, somewhat vase-shaped in the anterior portion, the extremity of which is inflated, largest in the middle and tapering in both directions; it is 5.25 mm. long, 1.8 mm. broad in the middle, 1.7 mm. at the anterior extremity and 1.25 mm. at the constriction; the anterior extremity reaches nearly to the alimentary reservoir, and is pretty strongly constricted before its inflation; just before its hinder extremity, which lies beneath the colon, it emits superiorly a tube, which, after some contortions, curves forward upon the alimentary reservoir for about 1.5 mm. and then expands into the subreniform, flattened, backwardly directed spermatheca, which lies upon the right side and terminates in a large tube a little longer than itself, opening into the oviduct. Into the

oviduct also opens on the opposite side a much smaller similar canal, conducting to a slight pyriform enlargement (the unpaired accessory gland), bearing at its tip a delicate thread. Immediately after this the oviduct is fed from above, and just below the commencement of the rectum, by a pair of vermiform, widely divaricating, heavy tubes (the paired accessory glands), each more than a millimetre long, and continuing as a tortuous thread, entering the tube at the middle of its anterior border. The vagina is a stout tube 0.75 mm. in diameter, 1.75 mm. long. At the extremity of the body, lying against the integument and between the opening of the vagina and the oviduct, is a transverse reniform vessel, attached broadly

by its base to the inferior wall of the oviduct at its very extremity; its left tip (and perhaps also its right—but this was ruptured in the specimen in which the other was seen) terminating in two little threads. I do not find notice of any such organ in a cursory examination of some of the writings of our principal entomotomists, unless the following passage from Siebold's *Anatomy of the invertebrata* (Amer. ed., p. 453) refers to the same: "Some Lepidoptera have, moreover, two smaller ramose glands, situated near the orifice of the vagina, which secrete, perhaps, an odorous substance that excites the copulatory act." A foot note specifies, "Melitæa, Argynnis, Zygaena, &c."

3. THE LARVA OF *POLYGONIA C-ALBUM*, OF EUROPE.

Digestive system. The stomach is more muscular than usual, being banded with longitudinal and transverse muscles made up of approximated fibres much larger than ordinary, one pair along the dorsal line larger than the others: it is 9 mm. long, while the intestine and rest of the alimentary canal posterior to it measures 3 mm., being longer than usual; the whole canal is 16.5 mm. long. The salivary glands are long and slender, thread-like tubes, at least 3.5 mm. long, imperceptibly tapering, and extending along the sides of the body in a slightly tortuous course to the middle of the third thoracic segment, where they appear to be closely connected with some of the tracheal tubes at the base of the latero-dorsal spines. The malpighian vessels take their rise from

a pretty large, irregular, subpyriform sac, slightly longer than broad, having a very slender neck-like attachment at the very base of the intestine; the lateral threads reach the front of the fourth abdominal segment; the superior and inferior threads nearly as far.

Nervous system. Each of the lobes of the cephalic ganglion appears to be globular, 0.4 mm. in diameter, perhaps shortest in transverse diameter. The lateral nerves arise from the cord in front of their respective ganglia by a distance greater than the diameter of the ganglion, and between the origin of the lateral nerves and the ganglia, the nervous cord is seen to be double. The distances apart of the body-ganglia are as follows, measured from centre to centre: 1-2, 1.2 mm.; 2-3, 1.2 mm.;

3-4, 1.25 mm.; 4-5, 0.5 mm.; 5-6, 1.5 mm.; 8-9, 2 mm.

Silk vessels. They agree in appearance with those of *Hamadryas* and reach the middle of the sixth abdominal segment, where they are attached.

Male generative organs. Testes pinkish red, the median line much deepest in color, longitudinally oval, nearly four times as long as broad, filled with a whitish granular matter, and situated in the middle of the fifth abdominal segment.

4. THE LARVA OF *AGLAIS URTICAE*, OF EUROPE.

Observations on the changes in the nervous system of this species, in passing from the larval to the pupal state and during the continuance of the latter, as also some statements regarding the structure of the tracheae, will be found in Newport's papers. See also other papers referred to in the introduction.

Digestive system. The under branch of the malpighian vessels passes along the under outer surface of the stomach as far as the hinder part of the second abdominal segment; the branch which extends along the upper outer wall of the stomach appears to extend as far only as the middle of the fourth abdom-

inal segment.

Nervous system. The last two abdominal ganglia are so closely united as to conceal their point of union, as in *Euphœeales troilus*; and in other respects they closely resemble that species.

Glandular system. The silk-vessels are of uniform size throughout, and they therefore do not present that distinction into two parts, a vessel and a conducting tube, which holds in *Danaïs*.

Male generative organs. The anterior thread of the testis is fully half as long as the testis itself, measuring one millimetre in length, while in *Hamadryas* no thread was found.

5. THE PUPA OF *AGLAIS URTICAE*, OF EUROPE.

Muscular system. The mesothorax is almost entirely given up to muscular bundles, the principal portion of which, for the movement of the future wings, is divisible into two sets. One of these sets is restricted to the lower part of the sides of the thorax, and its fibres are directed from the base of the wings toward the middle of the lower surface, those of the opposite sides inclining toward each other at a little more than a right angle. In the V-shaped space between them, and including all the upper domed part of the mesothorax,

is the other set, running longitudinally in five superimposed layers.

Digestive system. The tortuous intestine is 9.5 mm. long.

Male generative organs. The testis is extensively clasped by the tracheal vessels of the fifth abdominal segment. It looks as if made up of layers of fibrous material, more distinguishable because alternately darker and lighter; the anterior thread is one millimetre long, or fully half as long as the diameter of the testis. The testis is perfectly crammed with spermatozoa. These appear to be

coarsely striated throughout most of their mass and to be of two sorts. In one sort the length is 0.7 mm. and the breadth 0.03 mm.; the anterior extremity is rounded, commencing suddenly yet slightly to diminish in size at about 0.03 mm. from the end; while the slightly covered posterior extremity tapers gradually and regularly for a

distance of about 0.06 mm. to a blunt point. The other sort are shorter, club-like filaments, 0.145 mm. long, slightly curved, with a transparent peduncle 0.045 mm. long, and about 0.01 mm. in diameter, beyond which they rapidly expand to a club-like scale, sometimes 0.05 mm. broad.

6. THE LARVA OF *HAMADRYAS IO*, OF EUROPE.

Muscular system. From the anterior end of the inner strip of longitudinal body-muscles attached to the under surface of each segment, a slender ribbon of muscular fibres runs obliquely to the posterior end of the same segment and is attached at the ventral line. Just above the spiracles on each side there appear at first to be only two slightly separated muscular bands, the third, that lying next the tracheae, being very inconspicuous. The investing muscles of the stomach are thicker than in *Danais* and arranged in a manner resembling those of *Euphœades*.

Digestive system. At the middle of the seventh abdominal segment the alimentary canal suddenly contracts as in *Danais*, but immediately afterwards expands into a pyloric vessel and then again contracts; the stomach, when empty, is fusiform, and bears interiorly seven or eight longitudinal ridges; the intestine and colon together form less than one-fourth of the whole intestinal canal.

The salivary glands are beaded, circular, scarcely tapering tubes, 4.5 mm. long, straight, and following the sides of the oesophagus at the base.

The malpighian vessels originate in a reniform sac, one millimetre long, which

sends off a branch at right angles, a very short distance beyond its tip, and at a millimetre's distance further divides into two equal branches. The under branch passes forward in a tortuous course over the same track as in *Danais*, reaching a little way beyond the ganglion of the fifth abdominal segment.

Circulatory system. The dorsal vessel is free and very slender (about the size of the nervous cord) as far as the middle of the third abdominal segment, where it is attached above to the integument, and then suddenly expands to a much larger size, which it retains for some distance, and finally, in the seventh and eighth segments, expands again to a fusiform reservoir and then tapers to its extremity; in the head and first thoracic segment it is bordered by lobes of fatty matter composed of an amorphous mass of granulated material, differing from the alae of the dorsal vessel posteriorly, in that in the latter these granulations are mingled with and form part of cords of tissue running at right or nearly right angles to the dorsal vessel; the dorsal vessel is very elastic and flexible, and when one side is pulled, even pretty forcibly, the other remains in place.

(To be continued.)